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# THE COMING COPPER FAMINE

BY SYDNEY BROOKS

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THIS is a war of metals, and one vast and vital side of it, the side of munitions and material, will need for its proper telling a historian who is something of a metallurgist and a good deal of a manufacturer. He will have to show how it was the seizure, forty-five years ago, of the iron ore beds of Alsace-Lorraine that alone made it possible for Germany either to begin or to sustain the present war. He will have to trace out the immense advantages that accrued to her when in its first few weeks she overran Belgium, one of the most intensively industrialized countries in Europe, and seized all its workshops, its tools, its coal and iron mines; when she captured the coal-fields of northeastern France, the iron ore districts on the Lorraine frontier, and the great manufacturing city of Lille; and when the Pennsylvania of France, the region from which France derived three-fourths of her steel, had thus fallen into the enemy's hands. He will have to follow the effects of these prodigious developments the world over—in Britain, first of all, as the main workshop and arsenal of the Alliance, in America next as the chief producer of raw material, and lastly in every land whose resources, thanks to British sea-power, have been harnessed to the service of the Allies. The uses and properties of steel and copper, of antimony, lead and tin, of spelter, tungsten, and mercury and of a host of other metals and substances will have to be known to him; and the struggle to get them and to make the most of them will form one of the most amazing and fascinating volumes in his whole narrative.

Especially, for the drama there is in it, will he keep an assiduous eye on copper. If one cannot quite say of copper, as one can of steel, that it furnishes the base for the whole monstrous mechanism of modern war, one can at least say that among the indispensable metals in a belligerent's armory

it holds the second place. Every rifle cartridge case contains nearly half an ounce of the purest copper. Every bullet that flies from a machine gun has been enclosed in a casing of copper and zinc, gas-tight and exact to a five-hundredth part of an inch. Every shell that is fired, whether shrapnel, high explosive, or armor piercing, is encircled with a copper band to prevent contact between the shell and the gun-barrel and to ensure close fitting in the rifling. Every fuse has copper among its constituents; it is the chief element in Admiralty gun metal; for field telephones nothing else will do; and in war as in peace the whole electrical industry comes to a standstill without it.

Before 1914 Germany was producing on an average some 26,000 tons of copper. She may conceivably, and with the help of the Austrian mines, have increased her production to somewhat over 30,000 tons a year. But that is probably not much more than a fourth or a fifth of her imperative war needs. In normal times Germany required about 250,000 tons of copper annually. During the war, even after every domestic use of the metal had been restricted to a minimum, it is difficult to see how she could get along with less than from 125,000 to 150,000 tons, that is to say, between four and five times as much as she had ever raised from her own soil. For the past three and a half years, therefore, by no means the best of Germany's problems has been to make good an annual shortage of 100,000 tons of this prime military essential.

How far she has succeeded in solving it is, of course, unknown. But the methods she has adopted in attempting to solve it are by now fairly familiar. First, she drew on her accumulated stores. There cannot be much doubt that, having intended the war and prepared for it, Germany had canvassed its copper aspects in advance. In the five years before its outbreak she was an unusually heavy buyer of the metal. It has been ascertained that during that period she imported 200,000 more tons of copper than went into her export business. At what figure her reserves actually stood in August, 1914, one cannot tell. But they were unquestionably large enough to meet the demands of the brief, triumphant campaign on which the General Staff confidently counted.

Secondly, Germany proceeded to import all she could from neutral countries. That source of supply has by now been pretty well cut off, but in the early days of the war it

flowed freely. In September and October of 1913 Italy, the Netherlands, Norway and Sweden imported under 11,000,000 pounds of copper. In the same months of 1914 they imported over 52,000,000 pounds, and there can be little question that some of it, probably a good deal of it, found its way into Germany. The British blockade at that time was poorly devised and ineffectively enforced. The official list of contraband goods did not, for instance, include copper regulus or matte which might contain up to seventy per cent. of copper; and inexperience and an anxiety not to tread too heavily on America's toes forfeited in the matter of copper as with a good many other commodities some of the advantages of supremacy at sea. The temptation moreover to neutral exporters was irresistible. Even before the end of 1914 any one who could land a ton of copper in any form across the German frontier could get for it £160 paid down in gold.

But most of all the German Government relied on the ingenuity and self-sacrifice of its subjects at home and of their friends abroad to supply it with the copper it needed. The chemists and metallurgists and manufacturers were set to work to devise substitutes. As early as April, 1915, the Allies picked up on the battlefields many German fuses made not of copper but of aluminium with a small cap of iron. They were not altogether a success; the shells, being overlight at the point, too often fell sideways and failed to explode. In other directions German technologists may have had happier results in their search for an alloy to take the place of copper, but we shall have to wait till the end of the war before their efforts can be known and studied. Meanwhile the capture of some Serbian copper mines partially relieved the situation. The German Government paraded its acquisition for all it was worth, dispatched six thousand miners to its new treasure-trove with the utmost publicity, and did what it could to persuade the German people that mines which produced before the war hardly more than seven thousand metric tons and the machinery of which had been largely destroyed before their capture, would now meet the war requirements of the German Empire.

That pretence, of course, could not be kept up for long. The German people have had their shortage of copper very sharply brought home to them in their homes and daily lives, and they have shown a fine spirit in endeavoring to overcome it. Some enthusiast estimated in the early days of the war

that there were 2,000,000 tons of copper in domestic and manufacturing use in Germany. The Government at once took steps to get as much of it as it could. In Hamburg alone, over two years ago, there were twenty-nine stations for collecting copper utensils. In January, 1916, the surrender of all articles of copper, brass or nickel was made compulsory. Since then the whole Empire and all the conquered territories have been gone over with a fine tooth-comb in the search for copper.

The fifty-four castles and residences that belong to the Kaiser as well as the opera houses and theatres he subsidizes have been ransacked for the precious metal. Printers and publishers had to yield their "blocks." The cable tramways in Kiel and many other towns were torn up. The cathedral at Bremen was stripped of the copper in its roofing. Church bells have been pretty generally confiscated. The cemeteries have been searched for crucifixes, crosses and medallions. The holy-water basins in the Belgian churches have been requisitioned. Private householders were urged at first and then ordered to hand over all the copper saucepans, kettles, cauldrons, boilers, cooking utensils, door-knobs, bed-warmers, coffee machines, ash trays, chandeliers, and ornaments in their possession; and a vast service to art and humanity has been rendered by melting down many of the public statues in bronze and copper.

Outside the Fatherland German agents have been incessantly busy on the same quest. They were found over two years ago buying copper and bronze guns at Teheran, Ispahan and throughout Persia. In all the adjacent neutral countries they bought up copper coins by the bushels. The prisoners in German camps when writing home were made to ask for the oddly innocent gift of a copper saucepan. The very herdsmen's huts in the Swiss hills and valleys were visited by German emissaries on the lookout for stray copper utensils. All sorts of machinery were purchased by the German Government in contiguous countries provided that one-third of it was made of copper. Guileless orders for copper lamps and copper motor accessories were showered on the Scandinavian kingdoms. Danish engravers were startled one day by an order for a million copper plates, with the Kaiser's portrait engraved on each, to be shipped as "works of art."

Smuggling, of course, has gone on systematically. All Germany's neutral neighbors at a very early stage of the

war forbade the exportation of copper from their territories. Copper none the less has leaked over the frontiers in a thousand disguises. A Danish captain tried to run forty tons of it as sugar but the bottom dropped out of one of the casks and his game was stopped. Five Dutch subjects were arrested in February, 1915, for trying to smuggle copper under the cargo of a Rhine boat. Railway cars returning from Sweden to Germany were found to be fitted with double sides for holding copper. The British blockading squadrons have found copper buried in orange cases from Spain and hidden in hollow logs and candlesticks. They have intercepted steamers whose names were written in copper letters a foot long. They have unearthed the metal in bales of cloth and wool and bags of maize and linseed from South America, and just two years ago they seized two hundred packages of copper, each weighing five pounds apiece, which German sympathizers in the United States had sent by registered first-class mail to their friends in the Fatherland as a Christmas present.

All these somewhat desperate shifts tell their own tale. They mean that Germany, the greatest importer of copper in Europe, will when the war is over be absolutely bare of it. There is nothing, therefore, incredible in the report that German manufacturers or the German Government have already placed orders for 200,000,000 pounds in the United States for immediate delivery on the return of peace. Before the war nine-tenths of Germany's foreign supply of copper came from America, the supplementary sources on which she counted being Australia, Belgium, Japan, Serbia, and Great Britain, all enemy countries. The Allies, if they care to use it, have thus an immensely powerful weapon in their virtual monopoly of a raw material out of which Germany has built up a considerable export trade and the steady supply of which is indispensable to her industrial development at home.

What applies to Germany applies also to her Allies. The end of the war will find areas in Europe and Asia Minor inhabited by 150,000,000 people practically without a pound of copper among them. And when to these we add the territories that Germany has overrun and despoiled we get a population of not less than 200,000,000 in a state of copper famine. It is not easy to realize all that this means. Our great grandfathers would not have

minded the prospect. Three generations ago an output of less than 10,000 tons a year sufficed for the needs of the entire world. Nowadays we consume annually over 1,000,000 tons. Copper enters into our domestic and industrial lives in a hundred different ways on which the average man never wastes a thought. It is present in every article of brass and of bronze that we use. Wherever there is electricity copper is an essential element. In the existing state of applied science there could be no electrification of a single railway without a lavish use of copper for cables and fittings. Practically all the telegraph and telephone wires the world over are made of copper. It is the best conductor of electricity that so far has been discovered. Many experiments have been made with aluminium but as a conductor it has never yet been found either as economical or as lasting as copper. And apart from this one has only to think of the boilers, stills, cooking vessels, seamless pipes, nails, wire, etching and engraving plates, lightning-rods and writing pens that are made out of copper to get some idea of its manifold uses and importance and of the dislocation that would be caused were the supply to run short or the price to become prohibitive.

But these precisely are the developments with which the war threatens the world. Not only have great and populous regions been denuded of copper, but the production of the metal has been so vastly accelerated by the events of the past three and a half years that the exhaustion of the chief existing mines is now a matter of one or two decades, and no more. The United States at present produces some fifty-five per cent. of the total output. In February, 1914, five months before the outbreak of the war, Mr. Ryan, the President of the Amalgamated Copper Company, declared that the copper available in the United States would be exhausted in fifteen years. Since then the unprecedented demands of the belligerents must have considerably reduced his estimate of America's productivity. The copper output of the United States in 1913 was 557,000 metric tons. In 1916 it was 880,000 tons.

One must carry in one's head the copper statistics of the past hundred years to appreciate the significance of the situation that is now shaping itself. Three generations ago, as I just said, the world got along with an annual copper production of less than 10,000 tons. In the 'twenties some 13,000 tons sufficed; in the 'forties, 29,000; in the 'sixties, 90,-

000 tons. For the first seventy years of the nineteenth century the annual average consumption was 32,000 tons and no more. Then came the dawn of the electrical age and with it a vastly increased demand for copper. For the three closing decades of the last century the average annual production was nearly eight times as much as during the previous seven decades. From being 32,000 tons a year it rose to 240,000; during the first decade of the present century it increased still further, to all but 700,000 tons a year; and in the six years since 1910 it has averaged over 1,000,000.

Copper, in other words, has only won its position as an indispensable metal within the last forty or fifty years. Less than one-fourth of all the copper raised in the nineteenth century was produced in the first seven decades, and more than three-quarters in the remaining decades. Roughly, one may take 1870, or even perhaps 1880, as the beginning of the copper era. Between 1881 and 1890, for instance, its production increased by all but one hundred per cent.; in the following decade by an additional fifty-six per cent., and between 1901 and 1910 by a further eighty-eight per cent. In the past sixteen years the world's output has been nearly fifty per cent. greater than the entire production for the whole of the nineteenth century; and the figures for 1916 alone, showing a production of 1,450,000 tons, exceeded the total production for the twenty years between 1851 and 1870, and were some thirty per cent. greater than the figures for the whole of the ensuing decade between 1871 and 1880.

The demand for copper, then, while accentuated by the war, was not caused by it. It has been growing continuously, and at times almost violently, during the past four decades as part of the natural process of industrial development, for which the new uses that have been found for electricity are mainly responsible. It would have gone on growing even if there had been no war. What the war has done to copper is to accelerate its production, to divert a great deal of it from industrial to belligerent purposes, to impose a severe and unexpected drain on existing sources of supply and to create conditions in which, when peace returns, the world, needing copper more than ever, will have to draw heavily on its already depleted reserves.

This brings us to the question of how long these reserves are likely to last. Copper is found more or less all over the world's surface. There are believed to be vast deposits of it



in both the Arctic and Antarctic regions. It is being mined in Central Africa, in the United States, in Spain, in Chile, in Australia, in Japan, in Russia, in England, Scotland and Wales—in fact, the countries are few where it does not occur in greater or lesser quantities. On the other hand, the countries are fewer still where the beds are rich enough and accessible enough to have any appreciable effect on the world's supply. Not far short of sixty per cent. of the total copper production comes from the United States. That is one of the fundamental facts of the copper industry. Another is the predominance of the few big mines over the many smaller ones as factors in the total production. More than half the entire output—to be exact, fifty-six per cent. of it—comes from only seven per cent. of the companies engaged in copper mining, and sixty per cent. of the companies produce no more than six per cent. of the output. There are some three hundred and thirty-five copper mines working today. Of these, one hundred and thirty-nine, or forty-two per cent., produce less than 500 tons apiece per annum, while twenty-three mines have an average annual output of over 26,000 tons.

The big mine, then, and especially the big mine in the United States, is the main element, if not the crux, of the situation. If we take the six biggest American mines, which are together responsible for about a third of the American output, and calculate their known reserves of ore against their programme of future production, we find that they have before them an average life of no more than twenty-two years. If, again, we add to these half dozen mines the two giants in Chile, that are owned by American interests, we find that on the same basis their average period of productivity may be reckoned at twenty-seven years. That, however, is probably an extreme estimate, unless a policy of deliberate restriction of output is followed. If no such policy is adopted, if the supply is maintained on a level with the demand, then the copper required for the resumption of industrial life in Europe, where, as has been said, areas inhabited by 200,000,000 people will end the war practically denuded of the metal, must still further reduce the productive life of the Transatlantic mines to nearer twenty than thirty years.

A world without copper is inconceivable to the average man. He assumes without question that what has become a necessity of modern life will somehow or other continue to be produced as heretofore; that new mines will be discovered

and opened; that new methods will be invented for working lower-grade ores; that science will produce synthetic copper out of iodine and lead or zinc, or will devise some effective substitute; that copper sooner or later will be got direct from the ore without the intermediate processes of smelting or refining, and that in one way or another an adequate yield will always be forthcoming. And no doubt he is right. Is there any instance of an indispensable metal dropping out of existence through sheer exhaustion of the supply and without leaving behind something equally good to take its place?

On general principles the average man could make out a strong case. None the less, there are certain disquieting facts staring him in the face. The mines that at present produce sixty per cent. of the world's output have an active life that is definitely limited to between two and three decades. Other mines are known to exist, but in almost every case climatic conditions or their remoteness from communications render them unworkable. Metallurgists seem to agree that the extraction of copper from low-grade ores has already been carried pretty nearly as far as it can be. Thousands of laboratories are working on the problems of synthetic copper and of an efficient substitute, but so far without even a gleam of success. It takes at least five million dollars and five years of lavish capital expenditure before even a copper mine that has easy access to its market can be made productive. It takes much more, both of money and time, when the mine has to be linked with railways and roads to the outer world. Meanwhile, the demand for copper which has been mounting in great upward leaps for the past thirty years, has been immensely stimulated by the war, and after the war will develop into a world-wide and almost ferocious scramble. We are not faced with any immediate prospect of the disappearance of the metal. We are faced with the certainty of a shortage that among the nations which do not look ahead and guard themselves in advance will be little less than a famine.

The pressure of the world's needs upon the existing reserves of copper was a notable but little noted feature of the decade preceding the war. There are six countries—the United States, Germany, Great Britain, Austria-Hungary, France and Italy—that in 1903-4 consumed seventy-eight per cent. of the total output. Ten years later these same countries consumed eighty-seven per cent. In that decade, while the population had increased by only eleven per cent.,

their consumption of copper had increased by eighty-nine per cent. It had risen from 1.61 tons per each thousand of their peoples to just under three tons. If these countries were to carry on into the years of peace merely the normal increase of 43,000 tons of copper a year, which they averaged in the decade preceding the war, they would be consuming 1,607,000 tons in 1925, 1,808,000 five years later, and over 2,000,000 tons in 1935. But, as we have seen, their real demand is likely to be considerably in excess of this estimate.

We do not yet know how much copper any given country can consume. Hitherto the greatest intensity of consumption has been reached in the United States. It stood there in the year 1912 at 3.69 tons for each thousand of the population, having increased during the previous eight years at the rate of just over four per cent. per annum. If we were to take these figures—namely, a four per cent. increase each year and a per capita consumption of 3.69 tons for every thousand of the population—as representing the maximum that any country is likely to attain to, the estimate just given of the probable consumption of the six countries for 1925, 1930 and 1935 would require some reduction in the case of the first two years and a slight increase for the third. Perhaps if we place the copper needs of the world in 1935 at 2,500,000 tons, or nearly two and a half times the average output of the last six years, we shall not be very far wrong.

It is practically certain that the existing mines, even if they are worked to their fullest capacity, cannot in the next seventeen years rise to this level of production. But are they likely to be worked to their fullest capacity, or anything like it? So long as copper is indispensable, those who own copper mines may find it to their interest to limit the output, not in order to maintain prices, but to increase them. If we are really—as we seem to be—nearing a time when copper will be as relatively valuable as diamonds, the big American group that controls the copper production of the United States and Chile, and, therefore, of the world, may think it worth while to imitate the policy of De Beers. Copper in the past half century has been one of the greatest gambling counters of Wall Street, and the price of the metal has been famous for its sudden jumps. Forty-five years ago it reached \$540.00; twenty-two years later it touched bottom, at \$185.00; exactly ten years ago, in the space of nine months, it jerked up and down between \$530.00 and \$310.00. The coming years

may easily surpass all the Stock Exchange excitements that have been stirred up in the past by copper; anything that even resembles a find of the precious metal will be floated at once; but copper itself is likely for the rest of our lifetime to enjoy in the metal markets of the world a fairly stable price—the highest.

One thing only can prevent a hold-up of the entire world by the American copper magnates, and that is the discovery of fresh sources of supply. All over the earth men are prospecting for new deposits or reopening abandoned mines. Even in Great Britain, in the Lake district, in North Wales, in Argyllshire, the hunt is on. "There are few important metals," said the British Minister of Munitions, last June, "of which there is greater need for scientific and methodical development in this country than is the case with copper." But it is not Great Britain that can be looked to to mitigate the coming famine or loosen the American hold on the world's copper. The only country from which such possibilities can be expected is Russia, which stands today, so far as copper is concerned, just where the United States stood thirty-five years ago, and which, like the America of that date, possesses vast copper deposits that only await railways and capital for their development. Undoubtedly that development will take place. But for the moment Russia is an Empire in flux and too distracted to give a thought to her hidden industrial capacities, and it is too much to expect that her vast wealth of copper and other minerals can be exploited in time to avert a severe and universal shortage in one of the world's most essential metals.

SYDNEY BROOKS.